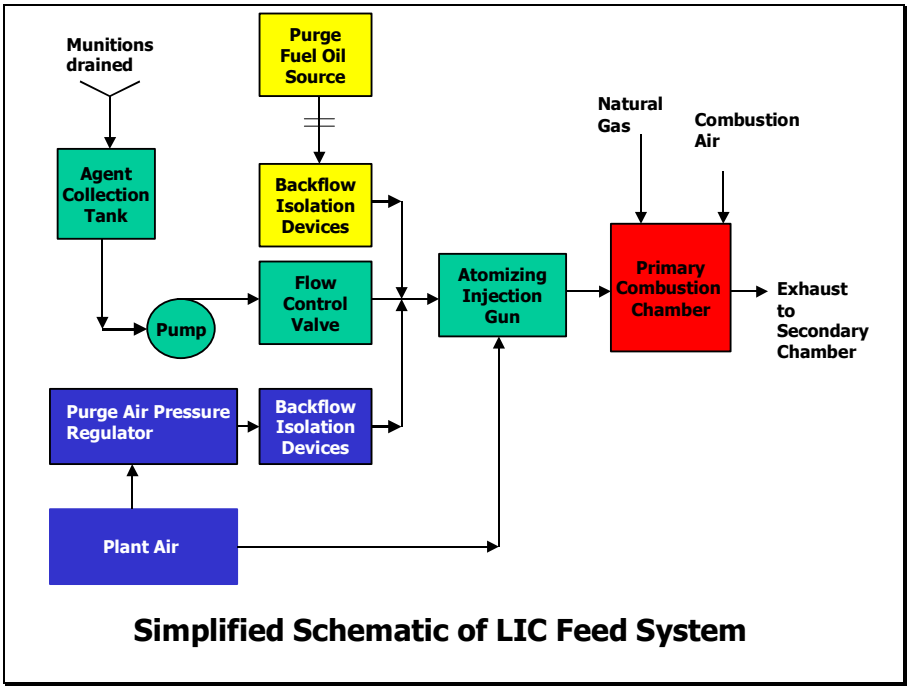
EXECUTIVE SUMMARY
July 15, 2002 Chemical Agent Exposure at
Tooele Chemical Disposal Facility (TOCDF)

Background

Destruction of chemical agent at TOCDF is accomplished by draining agent from munitions, straining and collecting the agent in one of two collection tanks, and pumping the agent into a liquid incinerator (LIC) where it is incinerated. There are two LICs, referred to as LIC 1 and LIC 2; the units are identical. Each LIC consists of two combustion chambers, a primary and a secondary, housed in separate rooms. The primary combustion chamber is used to incinerate chemical agent, the secondary combustion chamber is used as an afterburner for the primary and to incinerate spent decontamination liquid.

A pump draws agent from the first collection tank and injects it into the primary combustion chamber through an atomizing nozzle. After emptying the first tank, the pump is stopped, the agent remaining in the agent line is purged with air, and the pump is realigned to draw from the second collection tank. Air purging is controlled by a pressure regulator designed solely for use with air. To prevent backflow of agent into the air pressure regulator, backflow isolation devices (a series of check valves and a block valve) are contained in the air line. A fuel oil line is also attached to the agent line to allow flushing of residual agent in the system at the end of an agent-burning operation and prior to a controlled shutdown. During normal operation, in order to prevent agent backflow past the backflow isolation devices in the fuel oil line (identical to those in the air purge line) the fuel oil line is disconnected from the agent line by removing a flexible section of the line and attaching flanges (plates) to close the ends. The agent purge and flushing (air purge followed by fuel oil purge followed by air purge) cycles are automatically controlled through the Program Logic Control system. See simplified schematic below.



Simplified Schematic of LIC Feed System

Experience has shown that air purging causes a spike in carbon monoxide exhaust emissions, sometimes exceeding levels established in TOCDF's Resource Conservation and Recovery Act permit. The carbon monoxide spike causes an agent monitor in the exhaust stack to alarm. Since the alarm occurs outside of a chemical agent exclusion area, masking is required site-wide.

Permanent Changes (referred to as Engineering Change Proposals (ECPs)) and Temporary Changes are occasionally made to the technical baseline of the facility. In general, Temporary Changes are authorized for 30-day periods, after which time they must be extended or converted to an ECP. Following approval of a Temporary Change or an ECP, a Systems Engineer writes a Work Request. In response to the Work Request, maintenance Personnel prepare a Work Package. Additional permits are prepared by, and work and safety controls established by, personnel under the supervision of the assigned maintenance supervisor.

Sequence of Events

In the spring of 2001, an ECP was proposed to eliminate the carbon monoxide spiking and agent alarms caused by air purging. The ECP would eliminate the spiking by modifying the air pressure regulator to allow air purging to begin at a lower pressure. Acting as the Design Authority, the Program Manager for Chemical Demilitarization (PMCD) Field Office Manager approved the ECP for LIC 1 Primary on July 31, 2001 and for LIC 2 Primary on August 23, 2001. Work Requests for both ECPs were prepared at essentially the same time, limiting the ability to take advantage of the lessons learned from doing them one at a time. The repairs were to be done sequentially, but neither Work Request recognized the need to specifically review the results of the first repair (on the LIC 1 Primary) in order to reflect any lessons learned or experience in preparing the Work Package or work and safety controls for the second repair (on the LIC 2 Primary).

On August 28, 2001, a Work Request was prepared by Engineering to install the modified air pressure regulator assembly on the LIC 1 Primary. Destruction of agent GB was on-going. On November 8, 2001, the LIC 1 was taken off-line for installation of the modified air pressure regulator. Following system shut down and isolation, LIC cool-down, and decontamination, the modified air pressure regulator was installed. Following system re-activation and attaining system operating temperature, a function test was successfully completed on December 14, 2001. Destruction of agent GB was stopped in LIC 1 during this period, but resumed upon installation of the modified air pressure regulator assembly. The work in LIC 1 Primary was done in full personal protective equipment (PPE) (Level A, consisting of supplied air and a fully encapsulated suit). Agent GB was monitored with the TOCDF Automatic Continuous Air Monitoring System (ACAMS). Precautionary measures for responding to inadvertent contamination were available through the use of an installed shower system and decontamination equipment located at the standard LIC 1 Primary Room exit door.

On January 16, 2002, high levels of agent GB were detected in the LIC 1 Primary Room. Control room operators, using remote cameras, identified the source of agent leakage when agent GB was observed dripping from the newly installed modified air pressure regulator assembly, indicating that agent had migrated beyond established engineering ("agent expected" (AE)) boundaries in the air purge line. Agent feed to LIC 1 was stopped. Through engineering observations and analysis, it was determined that the check valves and block valve in the backflow isolation devices were "frozen" in the open position and could not be repaired. A Temporary Change was issued to fabricate and install a new set of valves to replace the leaking check valves and block valve. Full PPE was used and proper planning and precautions were taken. Although entries were made in the shift logs of January 16 and 17 describing the event

and the corrective actions taken, the piping and instrumentation diagrams (P&IDs) in the control room were not revised to reflect that agent had migrated beyond the "agent expected" boundaries in the air purge line.

Following a surveillance of these repairs, the PMCD Field Office sent a formal advisory letter to the System Contractor's Plant Manager on February 5, 2002 cautioning that the modification of the LIC 1 Primary air pressure regulator had been approved and was being planned for LIC 2 Primary and that measures should be taken to validate the integrity of the check valves and block valve through which agent migrated in the LIC 1 Primary for the LIC 2 Secondary before installing the modified air pressure regulator. The System Contractor did not respond to the letter, nor was it placed in the System Contractor's action tracking system or correspondence control tracking system. The System Contractor's Plant Manager forwarded the advisory letter to the LIC Systems Engineer. Neither the System Contractor nor PMCD Field Office personnel provided notification of this incident to PMCD's centralized lessons learned database.

GB destruction operations were completed in March 2002, after a five-year campaign (TOCDF's first), and changeover from destruction of agent GB to agent VX was started. The cleanup of installed pipes, tanks, and components included purging, flushing, and external surface decontamination. TOCDF's ACAMS was converted to monitor VX; the onsite medical facility, however, maintained both GB and VX monitoring capabilities.

In the spring of 2002, a Work Package was prepared to modify the air pressure regulator for LIC 2 Primary with the same design installed in LIC 1 Primary in December of 2001. No steps were included to verify the integrity of the two check valves and block valve, as previously suggested by the PMCD Field Office. The Work Order prepared by the LIC System Engineer did not mention the prior incident involving migration of agent into the LIC 1 Primary purge air regulator and the potential for a similar situation on the LIC 2 Primary. The System Engineer was not involved in the preparation of the maintenance Work Package and Safe Work Permit and did not attend the Pre-Entry Meeting. The Safe Work Permit was completed by the Maintenance Work Crew and approved by the Maintenance Supervisor. The P&ID used for planning this work showed the "agent expected" boundary in the air purge line to be downstream of the backflow isolation devices, but this condition was not verified. The LIC 2 Primary Work Package departed from the LIC 1 Primary Work Package in several aspects, including use of a lesser level of PPE, emergency egress from the LIC 1 Primary Room to the LIC 2 Secondary Room and then to an outside hallway as opposed to through the standard LIC 1 Primary Room exit door, use of a portable GB monitor, and no provision for temporary showers or decontamination materials at the egress route.

On July 15, 2002, two Maintenance Workers entered the LIC 2 Primary Room wearing Level E PPE (a full face industrial respirator approved by the National Institute of Occupational Safety and Health, overalls, and leather boots and gloves) to install the modified air pressure regulator. Concurrently, two Inspectors (the Inspection Team) entered the LIC 2 Secondary Room in Level F PPE (street clothes and slung respirator) to conduct unrelated inspection of other piping systems. The Maintenance Workers loosened the couplings (with wrench and by hand) for the 3-foot section of purge air line containing the existing air pressure regulator, removed the section of pipe, and placed it on the floor. Immediately the portable GB monitor alarmed and both Maintenance Workers exited to the LIC 2 Secondary Room, warning the two Inspectors to don their masks. The Maintenance Workers removed their industrial respirator and put on their government issued respirator. During the change of masks, some of the contamination from the leather glove of the Worker who had handled the pipe was transferred to his head, hair, and/or respirator. The Inspection Team finished their inspection and exited the LIC 2 Secondary Room

without undergoing monitoring or decontamination procedures. They were subsequently located (still within the Munitions Demilitarization Building (MBD)) and sent to the onsite Medical Clinic. The two Maintenance Workers remained in the LIC 2 Secondary Room. Although they changed masks and changed into clean coveralls, water or decontamination materials were not brought to the scene nor were Medical Personnel sent to observe the workers.

When the Maintenance Workers exited from the LIC 2 Primary Room to the LIC 2 Secondary Room, they failed to bring the portable GB monitor sampling line with them as specified in the Pre-Entry Checklist/Toxic Area Entry Permit. GB readings in the LIC 2 Primary Room were confirmed, and continued to be abnormally high. Portable GB monitoring capability was requested from Deseret Chemical Depot to assess GB levels in the LIC 2 Secondary Room and adjacent hallway. Monitoring arrived approximately 20 minutes later but was not the same type as used in TOCDF. Problems arose regarding the monitor readings when the instrument became saturated with agent and defaulted to a reading of 0.0. An additional reading was taken with the same results. Nonetheless, the Instrument Operator knew that high levels of GB vapor were present because the monitor, although defaulted to 0.0, flashed a warning that high levels of agent were detected. The System Contractor's On-Scene Incident Commander (OSIC), however, assumed the 0.0 reading meant a concentration of 0.0. A modified approach to take a smaller sample in a reduced timeframe was attempted, using a different monitoring device. The monitor indicated a low level of contamination for this reduced sample time, but the value was not accurately extrapolated to a normalized sample time, which would have indicated significant contamination levels.

About an hour after the initial alarm, the two Maintenance Workers were released from the LIC 2 Secondary, based on the inaccurate perception that they had cleared at least two monitoring cycles. They unmasked and were transported to the Medical Clinic without having undergone decontamination or preliminary medical evaluation. The two Inspection Team workers had cleared the Clinic Decontamination Vestibule with agent readings less than the Limit of Quantification (LOQ) and were in the Clinic Treatment Area when the two Maintenance Workers arrived at the Clinic Decontamination Vestibule. Upon the Maintenance Workers' arrival, GB monitors in the Clinic Decontamination Vestibule alarmed indicating that one or both of the Maintenance Workers were contaminated. The two Inspection Team workers were released from the Clinic Treatment Area after Medical Personnel determined they had not been exposed to agent. The two Maintenance Workers spent approximately 3½ to 4 hours in the Decontamination Vestibule undergoing repeated decontamination cycles before they were declared free of contamination and brought into the Clinic Treatment Area for evaluation. During their time in the Decontamination Vestibule, Medical Personnel observed the Maintenance Workers through windows from the attendant room but "face-to-face" evaluations were not conducted. Atropine was not administered as a prophylactic measure at any time. Once allowed into the Clinic Treatment Area, a doctor observed one of the Workers to have experienced miosis (reduction of eye pupil). Later it was learned he also experienced disorientation, headaches, blurry vision, tightness in the chest and a runny nose, but he did not report these symptoms to the medical staff while he was in the Clinic Decontamination and Monitoring Vestibules and under observation. Later, blood analyses indicated about a 25% depression of red blood cell cholinesterase from the worker's baseline. The miosis and red blood cell cholinesterase depression are indicative of exposure to GB.

Board of Investigation

In accordance with paragraph 1-7b of AR 385-40, this report is classified as a General Use Safety Accident Investigation Report of a chemical event.

The Board of Investigation was established on July 16, 2002, by the Assistant Secretary of the Army for Installations and Environment (ASA,I&E) pursuant to the authority vested in him by General Orders No. 3 (paragraph 8) dated July 9, 2002. The Assistant Secretary appointed the Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health (DASA,ESOH) as Board President and directed that he assemble a team to investigate this incident in accordance with AR 385-40. The Board consisted of personnel experienced in incident investigation, safety engineering, safety management, safety oversight, worker safety planning and procedures, decontamination, personal protective equipment, hazard communication, industrial hygiene, occupational medicine, and chemical agent monitoring; included were two representatives of the U.S. Department of Health and Human Services, which has a Congressional mandate for independent safety and health oversight of chemical demilitarization. The Board consulted subject matter experts on some of the more complex technical issues.

The purposes of the Board were to determine the causes of the July 15, 2002 incident during which a Maintenance Worker was exposed to chemical agent GB at TOCDF and to recommend corrective measures to preclude future reoccurrence of this and similar incidents at TOCDF. The Board reviewed Department of Defense, Department of the Army, PMCD, and System Contractor regulations and procedures, operational logs, monitoring data, work orders and procedures, Standard Operating Procedures (SOPs), training records, casualty care processes, material data, plant and utility general arrangements and P&IDs. The Board conducted interviews with twenty employees directly involved in and responding to the incident and management of both the System Contractor and the PMCD Field Office. The Board toured the facilities involved in the incident and photographed and analyzed scientific evidence, including chemical analysis of foreign matter on a respirator and work gloves and piping.

Conclusion

Two essentially identical air purge systems are associated with the LICs. A modification of the LIC 1 Primary air purge line air pressure regulator was performed during the months of November and December of 2001 while TOCDF was operating. Subsequent problems were identified in January 2002 that required additional repair to the system: agent was observed leaking from the modified air pressure regulator. This additional repair involved replacing two check valves and a block valve that were intended to prevent backflow of agent into the air purge system and replacing the air pressure regulator into which agent had leaked. Proper PPE and safety planning and procedures were used, and the repairs were done without incident. Three problems were, however, encountered. First, the modified air pressure regulator valve from which agent was observed leaking was never examined to determine the reason for the agent leakage. Second, the fact that agent was found to be present in a portion of the air purge system beyond the “agent expected” boundary was neither indicated in P&ID nor included in a lessons learned program. Third, the experience with the LIC 1 Primary air purge line check valves and block valve was not considered in preparing the Work Package for the modification of the LIC 2 Primary air purge line air pressure regulator. The PMCD Field Office advised the System Contractor that such action was prudent but did not require a formal response that appropriate actions, such as verification of integrity, were in fact incorporated into the work planning.

The major difference between the modification for the LIC 1 Primary and LIC 2 Primary was TOCDF’s status. In contrast to the situation in the LIC 1 Primary modification in January, when agent was present in TOCDF and TOCDF was operational, during the LIC 2 Primary modification in July TOCDF was in an extended outage making preparations for changeover to VX operations. When TOCDF was operational, a more cautious approach was used. Since

TOCDF was assumed to be decontaminated, a false assumption since only external surfaces were declared agent free, the modification was performed under a different set of procedures, and assumptions were made as to internal air system integrity without confirmation of such integrity, as was suggested by the PMCD Field Office in February. Furthermore, numerous sources of information existed, such as documentation in shift logbooks, that should have made Operating and Maintenance Personnel aware of the prior experience with back leakage but were not used. In addition, the Systems Engineer who was aware of the problems encountered with the first repair did not participate in the work planning, although he did prepare the Work Request for which the Maintenance Group wrote the repair procedure and prepared the necessary permits. Once the incident occurred and a worker was inadvertently exposed, additional weaknesses were identified in the onsite emergency response relative to monitoring, decontamination, and medical evaluation of contaminated individuals.